Automatic-Reloading Baseball Tee

Michael Aceto '24, Hale Hescock '24, Christopher Zaino '24
Professor John D. Mertens, Ph.D.
Trinity College Department of Engineering

Abstract

The project objective is to build a self-reloading and programmable height-adjusting baseball tee with computerized hitting performance diagnostics. The automatic reloading of baseballs onto the tee after each hit will enhance swing repetition. This contributes to a more efficient and productive practice experience for hitters. Design criteria includes an efficient reloading system, adjustable tee settings, and a precise capacity for ball storage. On the diagnostics side, our design will provide a computation of two baseball statistics, exit velocity and launch angle. This device caters to a diverse age group of both baseball players and coaches seeking to gain a competitive advantage by using a more efficient system for practice.

Budget & Parts Used

Used Parts	Price
Jumper Wires	$ 6.98
NEMA 23 Motor & TB6600 Motor Driver	$ 38.25
Drawer Slides	$ 17.52
DC Step Down Converter x2	$ 14.88
New Gear	$ 17.29
Rack & Old Gear	$ 31.02
Squared PVC	$ 23.69
Plastic Glue	$ 4.87
Motor Mount	$ 8.37
Neopreme	$ 20.20
5.5mm DC Female Wire Adaptors	$ 6.37
NEMA 17 Stepper Motor	$ -
PVC	$ -
L298 Stepper Motor Driver	$ -
Woodshop Wood Supply	$ -
Elegoo Arduino Compatable Microcontroller	$ -
Plastic Funnel	$ -
9V Battery	$ -
Varying Masses	$ -
L Brackets	$ -
Electrical Tape	$ -
Three-Pronged Rotor	$ -
Wire Managament Clips and Zip Ties	$ -
9V Battery to 5.5mm Female Port Converter	$ -
Small Breadboard	$ -
Push Buttons	$ -
Screws and Washers	$ -
Total	$ 189.44

*All parts without a price were either provided free or owned prior

Design Specifications

Top Height (in)	Middle (in)	Low (in)
43	36	26

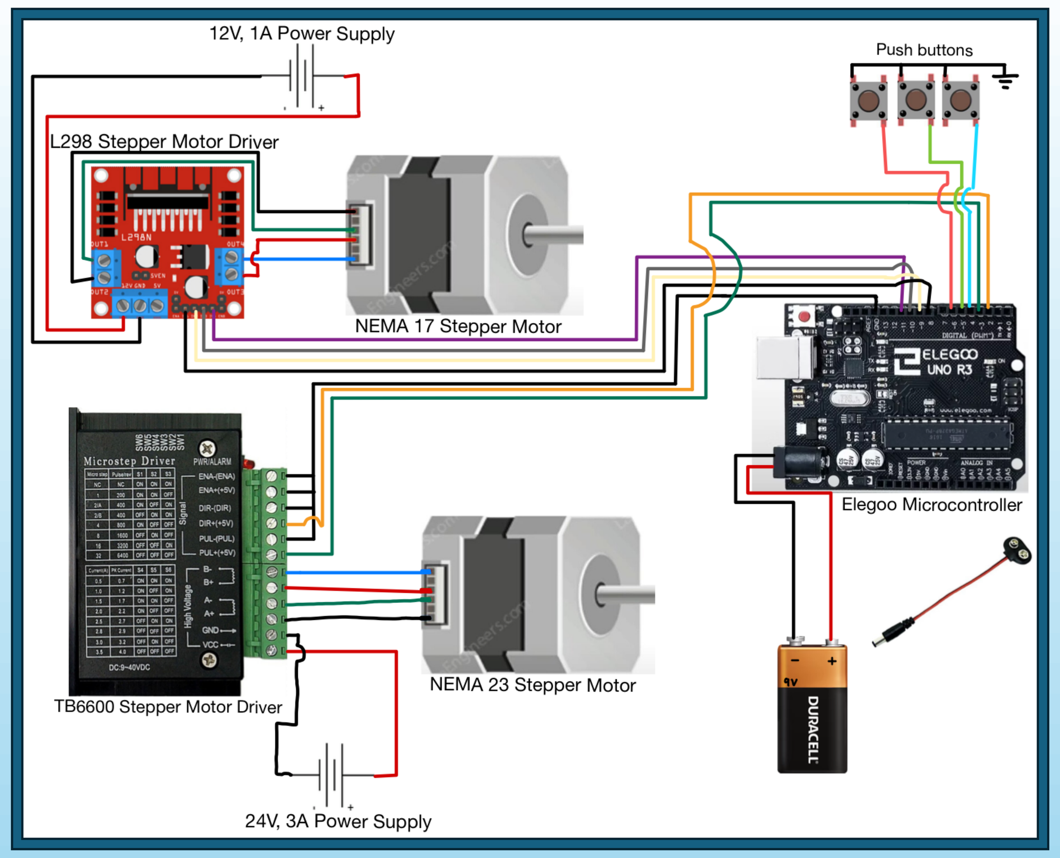
Our device can hold 6 balls. Default programming cycles through 3 heights, allowing the batter to hit at each preset height 2 times.

Vertical Adjustment Subsystem

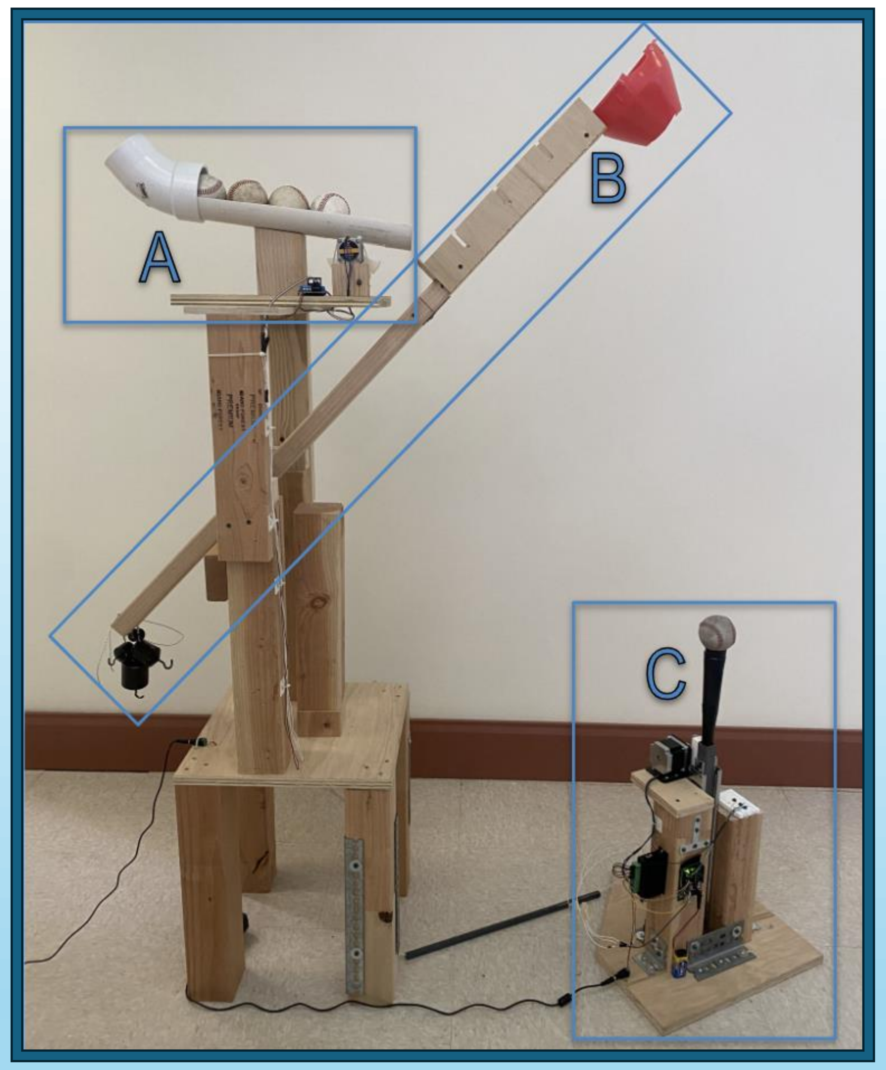
An Arduino code coordinates a stepper motor system. The motor, in turn, governs a rack and gear mechanism, ensuring fluid and precise adjustments to the tee's height. Initiated by a programmable button, the system guides the process through six ball iterations at three distinct heights: top, middle, and low.

System Components

Electrical Schematic

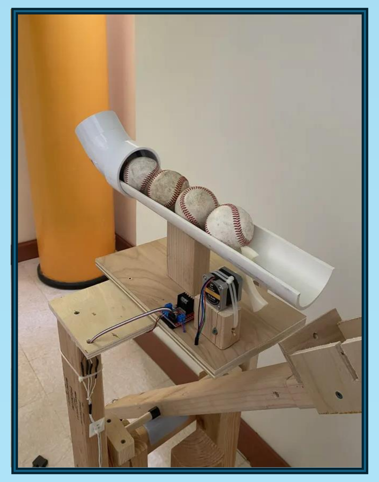


System Diagram



Unique Designs

Subsystem A:
Reloading



The stepper motor turns a three-prong rotor 120 degrees allowing for one ball to be released at a time.

Subsystem B:
Counterweight

The counterweight arm receives the baseball from the reloading system and precisely places the ball onto the tee.

Subsystem C:
Vertical Adjustment

Upon placement of the ball, a rack and gear design coupled with drawer slides allow for the vertical adjustment of the tee.

Frame-by-Frame Analysis

*See the Calculating Exit Velocity & Launch Angle Results section.

Results

Reloading

We ran a code for 100 reloads to determine the number of times a baseball was successfully reloaded on top of the tee.

Total Trials	# Correct placements	# Drops	Success Rate %
100	97	3	97

Counterweight

The counterweight system began with calculations using an Excel spreadsheet to determine optimal fulcrum placement for a wooden 2'' by 4'' beam. Torque calculations were performed for various masses to select suitable counterweights synchronized with the baseball's torque. Estimates for arm rotation time were derived from mass moment of inertia, angular acceleration, and angle of rotation. These calculations provided the basis for our design.

Length of beam: 1.32m
Fulcrum: 2/3 down beam
Mass: 1.875kg

$$T = Frsin\theta$$

$$I\ (beam) = \frac{1}{3}mr^2$$

Calculating Exit Velocity & Launch Angle

We calculated Exit Velocity and Launch Angle using basic trigonometric functions, an iPhone camera, MATLAB, and knowledge of the width, in inches, of the frame of the video. First, we equated a width to each pixel and noted the starting x,y pixel location and ending x,y pixel location. Using this and the frame rate of the video, along with the number of frames that the baseball was moving, we were able to calculate for both exit velocity and launch angle.

Calculated Exit Velocity (MPH)	Launch Angle	Actual EV (MPH)	Percent Error
76.21408611	7.524227222	66	15.47588805
70.39359423	5.112017748	70	0.562277466
78.62363901	3.188421059	80	1.72045124
74.12293613	4.169986143	80	7.346329843
74.72753024	1.747157052	81	7.743789832
78.80482849	1.959772308	82	3.896550619

References

- The MathWorks, Inc. (2023). *MATLAB version: 23.2.0 (R2023b)*. Accessed: J 04, 2024. Available: https://www.mathworks.com
- Ugural, A. C. *Mechanics of Materials*. J. Wiley & Sons, 2008.

Acknowledgments

- Professor Mertens
- Andrew Musulin
- Travelers Insurance